

REMARKS

In view of the following discussion, the Applicant respectfully submits that none of the presented claims now pending in the application is anticipated under the provisions of 35 U.S.C. §102 or made obvious under the provisions of 35 U.S.C. §103. Thus the Applicant believes that all of the presented claims are now in allowable form.

I. OBJECTION TO CLAIMS 1, 2, 9, 11, 12 AND 14

Claims 1, 2, 9, 11, 12 and 14 stand objected to for informalities. In response, the Applicant has amended claims 1, 9, 11, and 14, in accordance with the Examiner's suggestions, in order to more clearly recite aspects of the invention. Claims 2 and 12 have been cancelled without prejudice.

In particular, claims 1, 9, 11 and 14 have been amended, in accordance with the Examiner's suggestion, to recite a "three-dimensional, vertical stack of color sensors", replacing a "three-dimensional stack of color sensors".

Furthermore, claim 9 has been amended to recite a "color reflector ... positioned between the semiconductor substrate and the three-dimensional, vertical stack of color sensors", thereby clarifying that the semiconductor substrate is separated from the three-dimensional, vertical stack of color sensors by a color reflector positioned therebetween. Claim 14 has been amended similarly.

In view of these amendments, the Applicant respectfully requests that the objection to claims 1, 2, 9, 11, 12 and 14 be withdrawn.

II. REJECTION OF CLAIM 1 UNDER 35 U.S.C. §102

The Examiner rejected claim 1 under 35 U.S.C. §102(e) as being anticipated by the Merrill et al. patent (United States Patent on No. 6,841,816, issued January 11, 2005, hereinafter referred to as "Merrill"). In response, the Applicant has amended independent claim 1 in order to more clearly recite aspects of the present invention.

Merrill teaches a vertical color filter sensor group with non-sensor filter. The sensor group is formed on a substrate (e.g., a semiconductor substrate) and includes at least two vertically stacked, photosensitive sensors. At least one filter is positioned

between two of the sensors such that radiation propagated through or reflected from the filter propagates into at least one of the sensors.

The Examiner's attention is directed to the fact that Merrill fails to disclose or suggest the novel invention of separating a semiconductor substrate from a three-dimensional, vertical stack of color sensors by a color reflector, as positively claimed by the Applicant. Specifically, the Applicant's independent claim 1, as amended, recites:

1. An imaging sensor comprising a plurality of pixels, where each of said pixels comprises;
 - a semiconductor substrate; and
 - a three-dimensional, vertical stack of color sensors on the semiconductor substrate; and
 - a plurality of color reflectors, wherein each pair of adjacent color sensors is separated by one of said color reflectors, and wherein the semiconductor substrate is separated from the three-dimensional, vertical stack of color sensors by one of said color reflectors. (Emphasis added)

The Applicant's invention is directed to multi-spectral imaging with almost-full fill-factor using 3D pixels. Existing solid-state color imaging systems, which typically perform color imaging using pixel sensor elements and absorptive color filters, are prone to several limitations. For instance, color information obtained from a typical sensor element is less than optimal, because each sensor element takes up only a portion of a pixel's area. Moreover, the amount of light that is received by each sensor element is less than the amount of light impinging upon the associated pixel, because some of the light is filtered away by the absorptive color filters and because the sensor element typically has a less than 100% fill factor.

The Applicant's invention is an imaging device having pixels comprised of three-dimensional stacks of color sensors on semiconductor substrates. Each stack includes a plurality of color sensors and a wavelength sensitive color reflector positioned between each pair of sensors. Another reflector is positioned between the semiconductor substrate and the stack of sensors. In operation, incoming light is partially absorbed by a color sensor and converted to an electric charge. A portion of the unabsorbed light is reflected by the associated reflector and produces an additional

electric charge. The remainder of the unabsorbed light transmits through the reflector to the next sensor, where the light is treated in a similar manner by the next sensor and its associated reflector. This process continues until the light reaches the final reflector, positioned directly between the final sensor and the semiconductor substrate. Thus, light effectively passes twice through each sensor: first when the light is incoming, and then again when the light is reflected.

By contrast, Merrill fails to teach or suggest the need to pass light twice through each sensor. Specifically, the sensor taught by Merrill does not include a reflector positioned between the semiconductor substrate and the sensor stack.

As discussed, the Applicant's imaging device includes reflectors positioned not just between each pair of sensors, but also between the semiconductor substrate and the sensor stack. This improves the absorption of relevant light by each sensor in the stack, because at least a portion of the light that transmits through the sensor is reflected back to the sensor. Merrill, on the other hand, teaches positioning filters (which may be reflective of certain wavelengths) between sensor pairs only. Merrill thus fails to disclose or suggest the novel invention of separating a semiconductor substrate from a three-dimensional, vertical stack of color sensors by a color reflector, as claimed in Applicant's independent claim 1. Therefore, the Applicant submits that independent claim 1 fully satisfies the requirements of 35 U.S.C. §102 and is patentable thereunder.

III. REJECTION OF CLAIMS 2-17 UNDER 35 U.S.C. §103

The Examiner rejected claims 2-17 under 35 U.S.C. §103(a) as being unpatentable over Merrill. In response, the Applicant has amended independent claims 1 and 11, from which claims 3-10 and 13-17 depend, in order to more clearly recite aspects of the present invention. As discussed above, claims 2 and 12 have been cancelled without prejudice.

As discussed above, Merrill fails to disclose or suggest the novel invention of separating a semiconductor substrate from a three-dimensional, vertical stack of color sensors by a color reflector, as positively claimed by the Applicant. Applicant's independent claim 1 has been recited above. Applicant's independent claim 11, as amended, recites:

11. An imaging sensor comprising:
a semiconductor substrate having a plurality of crossing row and column conductors;
a row decoder for selectively applying potentials to a set of row conductors;
a column decoder for selectively reading charges on a set of column conductors;
a pixel matrix comprised of a plurality of pixels, where each of said pixels is located adjacent to one of said crossings of row and column conductors, wherein each pixel comprises:
a three-dimensional, vertical stack of color sensors on said semiconductor substrate; and
a plurality of color reflectors, wherein each pair of adjacent color sensors is separated by one of said color reflectors, and wherein the semiconductor substrate is separated from the three-dimensional, vertical stack of color sensors by one of said color reflectors; and
electrical connectors that electrically connect each color sensor to one of said row conductors and to one of said column conductors.
(Emphasis added)

As discussed above, Merrill fails to teach or suggest the need to pass light twice through each sensor. Specifically, the sensor taught by Merrill does not include a reflector positioned between the semiconductor substrate and the sensor stack. As discussed, the Applicant's imaging device includes reflectors positioned not just between each pair of sensors, but also between the semiconductor substrate and the sensor stack. This improves the absorption of relevant light by each sensor in the stack, because at least a portion of the light that transmits through the sensor is reflected back to the sensor. Merrill, on the other hand, teaches positioning filters (which may be reflective of certain wavelengths) between sensor pairs only.

The Examiner submits that it would have been obvious to one of ordinary skill in the art at the time the invention was made to place a color reflector between the semiconductor substrate and the three-dimensional stack of color sensors. The Applicant respectfully disagrees with this assertion and submits that Merrill in fact teaches away from such a configuration. Particularly, Merrill makes a point of noting certain advantages achieved by the filters that are placed below the first two sensors

(e.g., between a first sensor and a second sensor, and between the second sensor and a third sensor). However, Merrill makes no mention of such advantages being recognized or achievable with respect to the third sensor (e.g., the sensor positioned adjacent to the substrate). Any motivation or suggestion for placing a filter below the third sensor (e.g., between the third sensor and the substrate) to achieve similar results, or even to achieve different results, is conspicuously absent. Thus, the Applicant submits that Merrill does not contemplate or suggest the placement of a reflector anywhere other than between two sensors.

Merrill thus fail to teach, show or suggest the novel invention of separating a semiconductor substrate from a three-dimensional, vertical stack of color sensors by a color reflector, as claimed in Applicant's independent claims 1 and 11. Therefore, the Applicant submits that independent claims 1 and 11 fully satisfy the requirements of 35 U.S.C. §103 and are patentable thereunder.

Dependent claims 3-10 and 13-17 depends from claims 1 and 11 and recite additional features therefore. As such, and for at least the same reasons set forth above, the Applicant submits that claims 3-10 and 13-17 are not made obvious by the teachings of Merrill. Therefore, the Applicant submits that dependent claims 3-10 and 13-17 also fully satisfy the requirements of 35 U.S.C. §103 and are patentable thereunder.

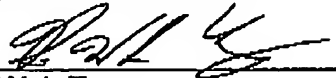
CONCLUSION

Thus, Applicant submits that none of the claims presently in the application are anticipated or made obvious under the provisions of 35 U.S.C. §102 and §103. Consequently, Applicant believes that all these claims are presently in condition for allowance. Accordingly, both reconsideration of this application and its swift passage to issue are earnestly solicited. If applicable, Applicant also reserves the rights to file one or more continuation applications for any canceled claims in the present application.

If the Examiner believes that there are any unresolved issues requiring adverse final action in any of the claims now pending in the application, it is requested that the Examiner telephone Mr. Kin-Wah Tong at (732) 530-9404 so that appropriate arrangements can be made for resolving such issues as expeditiously as possible.

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Respectfully submitted,


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